Ultrasound-Guided Proximal Suprascapular Nerve Block: A Cadaveric Study

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Difficulty in identifying the susprascapular nerve (SSN) limits the success of US-guided regional anesthetic injections. A proximal SSN block could be an effective and reliable approach. The primary objective was to validate the feasibility of the US-guided proximal SSN block. The secondary objective was to quantify the spread of the colored local anesthetic to the phrenic nerve (PN). Fourteen brachial plexuses from seven cadavers were included. Characterization of the proximal SSN was performed using US to determine the diameter and depth of the origin of the SSN (orSSN). Ten mL of methylene blue-infused ropivacaine 0.2% were then injected to the proximal portion of the SSN. After dissection, the distances between the tip of the needle and the orSSN and the PN were anatomically determined. The PN was also judged to be colored or not by the methylene blue. The mean diameter and depth of the orSSN were 0.2 cm (range, 0.1-0.3 cm) and 1.5 cm (range, 0.6-2 cm) respectively. The orSSN was successfully targeted in 14 of 14 specimens with US; the tip of the needle was a mean of 1.6 cm (range, 0.2-2.5 cm) and 5.1 cm (range, 4-6.5 cm) from the orSSN and PN respectively. The orSSN and PN were marked in 14 and 3 cases respectively. US-guided proximal SSN block is effective and reliable. The origin of the SSN is an easily identifiable landmark. This regional anesthesia could also reduce the risk of phrenic nerve palsy following interscalene brachial plexus block. Clin. Anat. 31:824–829, 2018.

Key words: brachial plexus; suprascapular nerve; regional anesthesia; ultrasound; phrenic nerve

INTRODUCTION

Regional anesthesia, obtained via suprascapular nerve (SSN) block is widely used in the management of acute, chronic, and recalcitrant shoulder pain (Chang et al. 2015; Fernandes et al. 2012). Indications for this type of anesthesia were initially limited to cases of post-operative shoulder pain but have expanded over the past two decades to include trauma-induced pain, adhesive capsulitis, and cancer (e.g., metastatic breast cancer) (Chan and Peng, 2011).

Recently, there has been an attempt to improve the accuracy of SSN blocks by using ultrasound (US)-guidance (Chang and Peng, 2011). However, the success of this

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type of anesthesia (Harmon and Hearty, 2007; Vorster et al. 2008; Siegenthaler et al. 2012; Battaglia et al. 2014) at the suprascapular notch (i.e., "distal" SSN block) is limited by the nerve's depth, and inconsistent anatomic variations in the origin of the sensory branches (Aszmann et al. 1996; Harmon and Hearty, 2007; Vorster et al. 2008; Chan and Peng, 2011; Siegenthaler et al. 2012; Rothe et al. 2014).

Laumonerie et al. (2017) recently demonstrated that US guidance was an appropriate modality with which to identify the origin of the proximal SSN (orSSN). Therefore, we speculate that the US-guided block of the supraclavicular portion of the SSN, also called the "proximal" SSN, may be a good alternative to the distal SSN block presuming the new method is found to be reliable and safe. Indeed, this latter could even supplant interscalene block (ISB), which is considered the gold standard in the management of postoperative pain after shoulder surgery, but is frequently associated with ipsilateral hemidiaphragmatic dysfunction because of the proximity of the phrenic nerve (PN). However, the PN palsy associated with the proximal SSN block remains to be defined.

The primary objective of this study was to validate the feasibility of the US-guided block of the proximal portion of the SSN via anatomic analysis. The secondary objective was to determine the risk of PN injury by assessing the dispersion of the anesthetic solution at the time of injection about the proximal SSN. The relevant hypotheses were that this method provides safe, reliable anesthesia without the risk of iatrogenic injury or unintended inclusion of the PN in the block.

MATERIALS AND METHODS

Fourteen brachial plexuses (BP) from 7 cadavers were included. The mean age of the 7 fresh-frozen cadavers (3 men, 4 women) was 82.9 years (71 94) with a mean BMI of 22.7 kg/m^2 (range, 19 31). A history of radiation to the brachial plexus, surgery, or trauma in the cervical, supraclavicular, or shoulder girdle area were considered as exclusion criteria. None of the specimens were excluded.

Anatomic Characterization and US-Guided Block of the Proximal Portion of SSN

An anesthesiologist (FF) with 15 years of experience in regional anesthesia characterized the 14 orSSN in seven cadavers using a linear high-frequency probe (10 12 MHz) (Edge II, Fujifilm Sonosite®, Inc., Bothell, USA).

The "ski lift" US protocol previously described by Lapègue et al. (2014), was defined a priori and used in all cases (Fig. 1). The cadavers were positioned supine, with the arm adducted, the head turned to the opposite side, and with no head or neck elevation. After identifying fascicles of the BP at the supraclavicular fossa, the US probe was translated proximally in the transverse axis to allow analysis of the fascicles, and then the trunks and roots of the BP. The "ski lift" method ends at the origin of the C5 and C6 roots where they make contact with the bifid transverse processes of the C5 and C6 vertebrae. Beginning with the C7 root, the BP origin is located in front of the non-bifid transverse processes (Martinoli et al. 2002). After the C5 and C6 roots were identified, the BP was re-explored in the opposite direction (i.e., proximal to distal scanning), resulting in back and forth scanning of the BP. The upper trunk of the BP was located by following the C5 - C6 roots to their convergence point. More distally, the SSN was traced from its origin to its most lateral portion before it entered the scapular region. US images provided us with an opportunity to measure the diameter and depth of the orSSN. The orSSN provided us with a landmark with which to identify and follow the supraclavicular portion of the proximal SSN as distally as possible. We subsequently inserted the needle parallel to the long axis of the probe and injected 9 ml of ropivacaine 0.2% colored with 1 ml of methylene blue (MB), for a total of 10 ml (Martin Wiegel et al. 2017), into the proximal SSN in all 14 cases (Fig. 1). The depth and diameter of the SSN at the level of the injection were also measured under US-guidance.

Brachial Plexus (BP) Dissection after Injection of the Proximal SSN

Cadaveric dissection of the BP via an anterior supraclavicular approach was performed (Shin and Spinner, 2005). The skin incision paralleled the lateral edge of the sternocleidomastoid muscle and extended parallel to, and approximately an inch above, the clavicle. The soft tissues were dissected until the distal end of the needle was encountered. The extent of dispersion of the 10 ml of colored mixture was identified after dissecting the supraclavicular and interscalene portions of the BP; the distance between the marked area and the PN was also noted. The mesoneurium was not preserved during this dissection. The following parameters were described in millimeters: (1) minimum distance between the orSSN and PN, (2) position of the needle tip, (3) minimum distance between the needle tip and the orSSN and (4) phrenic nerve. Distances were measured with a caliper.

Statistical Analysis

Statistical analyses were performed using Excel (Microsoft, Redmond, WA, USA) and XLSTAT 2011 (Addinsoft SARL, Paris, France) software packages. The primary and secondary objectives were to describe the dispersion of the contrast material with respect to the origin of the SSN and the PN, respectively. Results were described according to their means, and their minimum and maximum values.

RESULTS

The mean diameter and depth of the proximal SSN at the site of injection were 0.2 cm (range, 0.1 0.3 cm) and 1.5 cm (range, 0.6 2 cm) respectively. The minimum distance between the orSSN and the phrenic nerve was 3.6 cm (range, 2.5 6.4 cm). The proximal SSN was marked in 14 of 14 cadaver BP

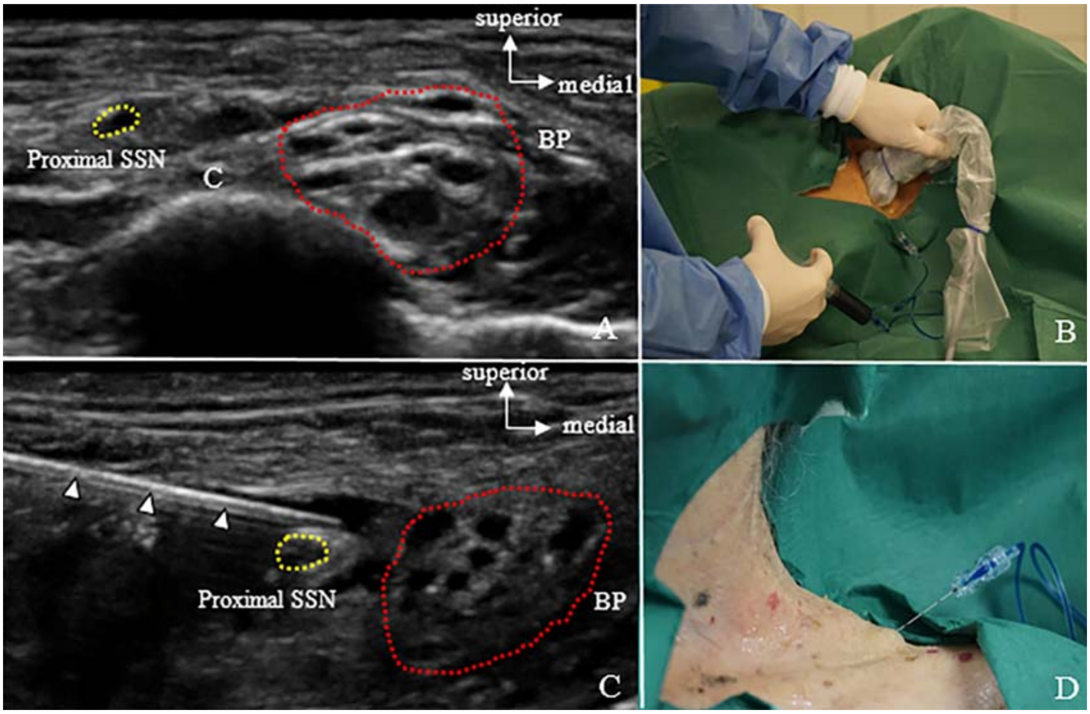

Fig. 1. Proximal SSN Block. **(A)** The proximal part of the SSN was identified according to the "ski lift" ultrasound protocol. Please notice the short distance between the proximal SSN (yellow dotted line) and the Brachial Plexus (PB) (red dotted line). **(B)** A linear high frequency probe allowed us to realize the ultrasound guided proximal SSN block in the supraclavicular fossa. **(C)** Needle (arrow head) was introduced along the long axis of the probe and ten milliliters of ropivacaine 0.2% colored with methylene blue were injected to surround the SSN realizing a hypoechoic puddle. **(D)** At the end of the procedure, the needle was left in place to guide the dissection to the marked area. C, Clavicle. [Color figure can be viewed at wileyonlinelibrary.com]

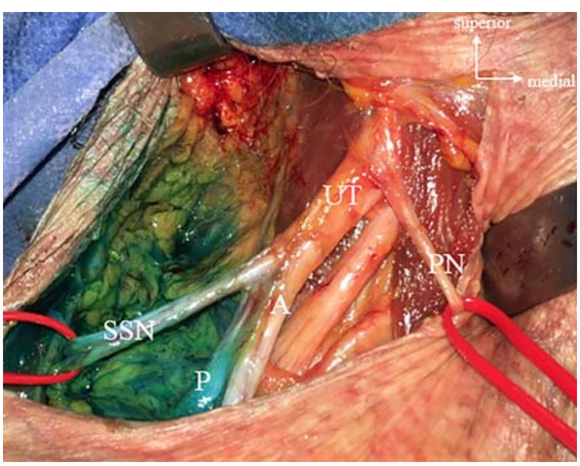

Fig. 2. Marking of the proximal SSN after ultrasound-guided injection of local anesthetic with methylene blue (BM) in cadaver specimen No. **7**. The SSN and the posterior (P) division of the upper trunk (UT) were marked with MB, respectively; the anterior division of the upper trunk (A), and the phrenic nerve (PN) were both spared from marking. [Color figure can be viewed at wileyonlinelibrary.com]

(100%) (Fig. 2). The needle was fixed in all 14 SSN and located at a mean minimum distance of 1.6 cm (range, 0.2 2.5 cm) and 5.1 cm (range, 4.0 6.5 cm) from the orSSN and PN, respectively. The minimum distance between area marked with methylene blue and the PN was 1.4 cm (range, 0 3.1 cm).

Dispersion of the MB dye was limited to the supraclavicular zone in 11 cases (78.6%) and the interscalene zone in 3 cases (21.4%). There were no cases of intravascular injection. The following adjacent nerves were marked: the upper trunk BP and its branches (SSN, anterior and posterior divisions - 14 cases, 100%) (Fig. 2), the middle trunk (13 cases, 93%), the PN (3 cases; 21.4%) (Fig. 3). The lower trunk and long thoracic nerve were not marked (0 case). Data are summarized in Table 1.

DISCUSSION

Our primary and secondary hypotheses were confirmed. US-guided proximal SSN block is a reliable and safe method.

Regional anesthesia of the distal SSN is an established treatment for addressing a wide range of chronic and acute postoperative shoulder pain conditions (Chan and

Fig. 3. Marking of the phrenic nerve (white arrow) after ultrasound-guided proximal suprascapular nerve block with local anesthetic plus methylene blue (MB) in cadaver specimen No. 12. The interscalene and supraclavicular portions of the brachial plexus (yellow tape) were marked with MB. [Color figure can be viewed at wileyonlinelibrary.com]

Peng, 2011). However, the SSN is quite deep at the level of the suprascapular notch (deeper in patients with a higher BMI); its anatomic location and proximity to the suprascapular artery are inconsistent (Harmon and Hearty, 2007; Vorster et al. 2008; Siegenthaler et al. 2012; Battaglia et al. 2014; Rothe et al. 2014). In 50% of cases, the origin of the sensory branches of the SSN is proximal to the suprascapular notch (Aszmann et al. 1996; Harmon and Hearty 2007; Vorster et al. 2008; Cahn and Peng 2011; Siegenthaler et al. 2012; Rothe et al. 2014). These factors make US-guided procedures more challenging and limit their efficiency, especially in obese patients. We speculated that a proximal approach for regional anesthesia of the SSN could be a reliable, novel method, provided it is demonstrated to be safe and effective.

The development of high-frequency US probes and high-definition US machines has had a significant impact on the study of superficial nerves (e.g., median, radial, ulnar, and common peroneal). Multiple authors have previously characterized the superficial course of the SSN (Table 1) (Schneider-Kolsky et al. 2004; Chan et al. 2011; Rothe et al. 2014; Laumonerie et al. 2017). We confirmed these findings; however the mean depth of the SSN (1.5 cm (range, 0.6 2.3 cm)) in our study was approximately double that identified by Faruch et al. (2017). Despite this increased depth, we were able to achieve 100% accuracy of US-guided ink marking of the proximal SSN, confirming that dynamic analysis of the proximal SSN is accurate and reproducible (Laumonerie et al.2017). The injection needle was consistently located distal to the orSSN in an effort to increase the distance of the anesthetic fluid from the PN while maintaining the utility of the orSSN as an anatomic landmark (Table 1). We advocate for the use of the orSSN as a landmark for US-guided regional anesthesia of the supraclavicular portion of the SSN. It is important to note, however, that the injections in the present study were performed by a highly experienced operator (Faruch et al.2017; Laumonerie et al.2017). Due to this, we recommend that the technique and interpretation of BP anatomy on US be mastered in order to obtain satisfactory results (Schneider-Kolsky et al. 2004; Chan et al. 2011; Lapègue et al. 2014; Rothe et al. 2014).

At the C6 level (cricoid cartilage), the phrenic nerve is situated at a mere 0.18 cm anterior to the brachial plexus. As the two neural structures move caudally, they diverge from each other at a rate of 3 mm for every centimeter below the cricoid cartilage (Q.H. Tran, Reg Anesth Pain Med 2017). The mean minimum distance between the marked tissue and the PN was 1.4 cm (range, 0 3.1 cm); the PN itself was infiltrated with methylene blue in three cases (21.4%) (Fig. 4). ISB is the most common regional anesthetic technique; however, phrenic nerve palsy and hemidiaphragmatic paresis have traditionally been inevitable consequences, which limit its utility in the population of patients at high risk of respiratory complications (El-Boghdadly et al. 2017, Ferré et al. 2017). The incidence of transient PN palsy approaches 100% after landmark- and paresthesia-guided ISB techniques, and 25% to 51% with superior

TABLE 1. Characterization of local anesthetic plus methylene blue dispersion about the proximal SSN.

Specimen No.	Age (Years)	BMI (kg/ m^2)	Depth OrNSS (cm)	Needle position	OrNSS marked	PN marked	Distance Needle-orNSS (cm)	Distance Needle- PN (cm)	Distance Marquage-PN (cm)
1 (Left)	71	25.4	0.99	SSN	Yes	No	1.8	5.1	1.5
2 (Right)	71	25.4	0.99	SSN	Yes	No	1.5	5.0	1.0
3 (Left)	94	18.7	0.60	SSN	Yes	No	2.5	5.8	2.1
4 (Right)	94	18.7	0.80	SSN	Yes	No	1.8	5.5	1.8
5 (Right)	85	18.4	0.91	SSN	Yes	No	0.2	6.5	2.8
6 (Left)	85	18.4	0.73	SSN	Yes	No	2.0	5.2	3.1
7 (Right)	80	29	2.3	SSN	Yes	No	1.2	4.5	1.8
8 (Left)	80	29	2.3	SSN	Yes	No	2.0	6	2
9 (Left)	84	22.9	1.6	SSN	Yes	No	1	6.4	1.8
10 (Right)	84	22.9	1.5	SSN	Yes	Yes	1.0	4.6	0
11 (Left)	81	20.1	0.6	SSN	Yes	No	1.5	4.1	1
12 (Right)	81	20.1	1	SSN	Yes	Yes	1.3	4.5	0
13 (Left)	85	24.5	1.1	SSN	Yes	No	1.5	4	0.8
14 (Right)	85	24.5	1.1	SSN	Yes	Yes	1.1	4	0

trunk blocks targeted at the supraclavicular brachial plexus (Urmey et al. 1991 and El-Boghdadly et al. (2017). Our results suggest that the injection of 10 ml of ropivacaine 0.2% at a minimum distance of 1.6 cm (range, 0.2 2.5 cm) from the orSSN could reduce the rate of transient PN palsies by >75% compared to ISB (Urmey et al. 1991; El-Boghdadly et al. 2017). Proximal SSN block could be of major interest in the management of postoperative pain after shoulder surgery in certain high-risk populations with restrictive pulmonary insufficiency.

This study is subject to the inherent biases associated with cadaveric studies. Additionally, we acknowledge that the US is an operator-dependent modality (Ohana et al. 2014; Tagliafico et al. 2016). A single, experienced anesthesiologist performed all the US characterization and regional anesthesia in this study; therefore, intra-class correlation could not be calculated. Elevation of the head and neck is known to improve visualization of the SSN (Lapegue et al. 2014), but such positioning was not possible with the cadavers in our study. Furthermore, the lack of visible blood flow during US exploration made it more challenging to describe the SSN and its surrounding vascular structures. Pleuro-pulmonary injuries are a classic complication of supraclavicular loco-regional anesthetic techniques; however, these were not evaluated in the present study. The cadaver dissection step may have modified the normal anatomy and/or the needle's positioning, which may have distorted the study's findings. According to Wiegel et al. (2017) the local anesthetic volume injected at the time of proximal SSN block was 10 ml. A smaller volume would have decreased the rate of PN marked by limiting the spread of the solution. The ceiling dose for proximal SSN block remains to be defined.

CONCLUSION

The method of US-guided supraclavicular regional anesthesia described herein is safe and reliable. The orSSN is an important landmark for tracking the proximal SSN. Though rare in our series, the potential for anesthetic dispersion in the territory of the PN when anesthetizing the proximal SSN remains an important consideration. As our ability to visualize the orSSN improves, ultra-low volumes and doses of local anesthetic may further minimize the risk of phrenic nerve palsy. Further studies are needed to determine the optimal dose for successful anesthesia of the proximal SSN, while avoiding inclusion of the PN in the block.

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